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XXXVII. *Experiments on mixing Gold with Tin. In a Letter from Mr. Stanesby Alchorne, of his Majesty's Mint, to Peter Woulfe, Esq. F. R. S.*

Read June 24, 1784.

DEAR SIR,

Tower of London,
March 25, 1784.

YOU know it is a generally received opinion among metallurgists, that tin has a property of destroying the ductility of gold, on being melted with it, even in very small quantities. Our late ingenious countryman Dr. LEWIS, in his *Philosophical Commerce of Arts*, p. 85. has well expressed the sense of most writers on this subject, in the following words: "The most minute proportion of tin and lead," says he, "and even the vapours which rise from them in the fire, though not sufficient to add to the gold any weight sensible in the tenderest balance, make it so brittle that it flies in pieces under the hammer."

Divers circumstances, nevertheless, long since induced me to disbelieve the fact; but these, having chiefly arisen from small experiments, did not seem to warrant any general conclusion. A late public occasion, however, which led me to various trials of mixing these metals together, in different proportions, and in sufficiently large quantities, has put the matter out of dispute; and shewn me, that tin, in small quantity at least, may be added to gold, either pure or alloyed, without producing any other effect than what might easily be conceived,

ceived, *à priori*, from the different texture of the two metals. In confirmation of which, I beg leave to lay some of the experiments before you.

EXPERIMENT I.

Sixty Troy grains of pure tin were stirred into twelve ounces of refined gold, in fusion; and the mixture was then cast into a mould of sand, producing a flat bar, one inch wide, and one-eighth of an inch thick. The bar appeared sound and good, suffered flattening under the hammer, drawing several times between a large pair of steel rollers, and cutting into circular pieces, of near an inch diameter, which bore stamping in the money-press, by the usual stroke, without shewing the least sign of brittleness; or rather with much the same ductility as pure gold.

EXPERIMENT II.

Ninety grains of like tin were added to twelve ounces of fine gold, stirred, and cast as above. The bar produced was scarcely distinguishable from the former, and bore all the operations, as before-mentioned, quite as well.

EXPERIMENT III.

One hundred and twenty grains of fine tin were mixed with twelve ounces of fine gold, and being cast like the foregoing, produced a bar rather paler and harder than the preceding, but which suffered the like operations very well; except that, on drawing between rollers, the outer edges were disposed to crack a little.

E X P E R I M E N T I V.

One hundred and forty grains, or half an ounce, of the like grained tin, were mixed, as before, with twelve ounces of fine gold; and the bar resulting from this mixture was completely sound and good; evidently paler and harder, however, than any of the foregoing, and cracking rather more than the last on passing between the rollers; but bearing every other operation, even stamping under the press, by the common force, without any apparent injury.

E X P E R I M E N T V.

One ounce of tin was next stirred into twelve ounces of the like refined gold, and then cast as before; but the bar produced, though seemingly solid and good, was bad coloured, brittle in texture, and, on the first passing between the rollers, split into several pieces, so that no farther trials were made with it.

E X P E R I M E N T V I.

To inquire how far the fumes of tin, brought into contact with the gold, would do more than mixing the metal in substance, a small crucible, filled with twelve ounces of standard gold, $\frac{1}{4}\frac{1}{2}$ fine, was placed in a larger crucible, having one ounce of melted tin in it, and kept there in fusion, the whole being covered by another large inverted crucible, for about half an hour. In this time a full quarter part of the tin was calcined; but the gold remained unaltered, and equally capable of being manufactured as another portion of the same gold melted in the common manner.

It may well be asked, whether the tin, or part of it, in every trial, might not be destroyed, and thus render the conclusions fallacious? But as, in any of these experiments, not more than six or eight grains of the original weight were missing after the casting, and as even fine gold can scarcely be melted without some loss in the operation, so we may reasonably suppose, that our small losses, in the foregoing trials, do not deserve consideration.

The above experiments then seem to shew, that tin is not so mischievous to gold as hath been generally represented. But it would be unfair to infer, that the original author of this doctrine (from whom so many have implicitly transcribed) had no foundation for the assertion. Gold and Tin, indeed, are substances pretty well known; but it is easy to imagine, that coins or trinkets may have been used for one, and impure tin, or pewter, perhaps, for the other; and it is difficult to guess what might be the result of such uncertain combinations. To inquire farther, therefore, the experiments were continued as follows.

EXPERIMENT VII.

To determine whether the two metals might be more intimately combined, and the mass rendered brittle, by additional heat; the mixture of gold and tin, produced in the first of these experiments, was re-melted in a stronger fire than before, and thus kept in fusion full half an hour. By this operation six grains only were lost in the weight; and the bar obtained was no less manufacturable than at first.

EXPERIMENTS VIII. AND IX.

The mixtures of gold and tin, from the second and fourth experiments, were re-melted separately, and one ounce of copper added to each. Being both well stirred, they were cast as usual; and the bars, though sensibly harder, bore all the operations of manufacturing as before. The last bar cracked a little at the edges, on drawing through the rollers, as it had done without the copper, but not materially, and bore cutting rather better than in its former state.

EXPERIMENTS X. AND XI.

A quarter of an ounce of the last mixture (being tin half an ounce, and copper one ounce, with gold twelve ounces), and as much of the bar from experiment the third (being tin one hundred and twenty grains with gold twelve ounces), were each melted by a Jeweller, in the most ordinary manner, with a common sea-coal fire, into small buttons, without any loss of weight. These buttons were forged by him into small bars, nealing them often by the flame of a lamp, and afterwards drawn each about twenty times through the apertures of a steel plate, into fine wire, with as much ease as coarse gold commonly passes the like operation.

EXPERIMENT XII.

To enquire whether the adding of tin to gold, already alloyed, would cause any difference, sixty grains of tin were stirred into twelve ounces of standard gold, $\frac{1}{4}$ fine; and the result passed every operation before described, without shewing the least alteration from the tin.

For greater certainty, several other trials were made, of different mixtures of copper, tin, and silver, with gold, even so

low as two ounces and a half of copper, with half an ounce of tin, to twelve ounces of gold. But these are not worth particularizing; for they all bore hammering, and flattening by rollers, to the thinness of stiff paper, and afterwards working into watch-cases, cane-heads, &c. with great ease. They all, indeed, grew more hard and harsh, in proportion to the quantity of alloy; but not one of them had the appearance of what all workmen well know by the name of brittle gold. Whence it should seem, that neither tin in substance, or the fumes of it, tend much to render gold unmanufacturable.

Whenever, therefore, brittleness has followed the adding small quantities of tin to fine gold, it must be supposed to have arisen from some unfriendly mixture in the tin, probably from Arsenic; for other experiments have shewn me, that twelve grains of regulus of arsenic, injected into as many ounces of fine gold, will render it totally unmalleable.

From the foregoing experiments, I presume, we may fairly conclude, that though tin, like other inferior metals, will contaminate gold, in proportion to the quantity mixed with it, yet there does not appear any thing in it specifically inimical to this precious metal. And this being contrary to the doctrine of most chemical writers, I submit to your better judgement, whether it may not be useful to publish these experiments, by laying them before the Royal Society.

I am, &c.

S. ALCHORNE.

